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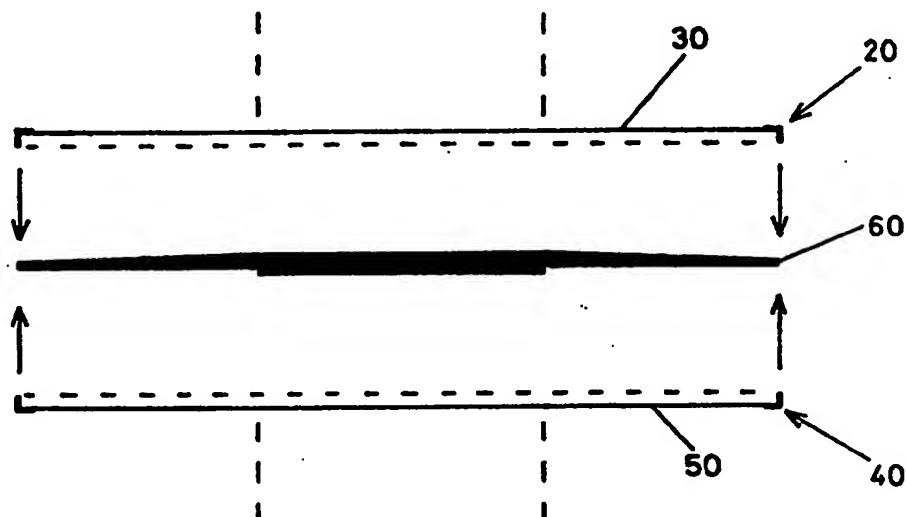
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(54) Title: SEMI-PERMANENT ENCLOSURE FOR OPTICAL DATA STORAGE DEVICE



(57) Abstract

A semi-permanent enclosure for an optical data storage device (60) comprises a first film (50) dimensioned to overlie the read surface of device (60) and a second film (30) dimensioned to overlie the non-read surface. The enclosure includes rim means (20, 40) having an L-shaped cross section extending around the periphery of device (60). Film (50) may have optical couplant on the surface thereof destined for attachment to device (60) in use. The optical couplant preferably has a refractive index compatible with that of device (60) to minimise losses and distortion of signals. Optical couplant may also be used with second film (30). The optical couplant may be a material capable of flowing into minor defects on the surface of device (60). This allows minor blemishes to be repaired so that stored data is not compromised. Alternatively, the optical couplant may be a solid malleable material interposed between device (60) and the film(s) or may comprise the film itself.

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SEMI-PERMANENT ENCLOSURE FOR OPTICAL DATA STORAGE DEVICE

The present invention relates to optical data storage media such as compact discs and, in particular, to a semi-permanent enclosure for protecting the edges and faces of such data storage media during use. The invention also relates to a method of repairing minor surface defects and/or blemishes in
5 optical data storage media.

Optical data storage media are becoming increasingly commonplace in everyday life. They are generally planar devices and have a substrate of clear plastics material or glass on which a surface formation of data "pits" is provided. The pitted surface is coated with a layer of diffused metal, such as
10 aluminium, which serves to reflect incident light passing through the substrate from its opposing face. Data is generally read by a laser shone through the clear plastics material or glass, the incident light being distorted by the data pits and then reflected from the mirrored surfaces to be read by a pick-up.

For simplicity, in the text which follows, the term "disc" is used in a non-limiting sense to refer to optical data storage media of various types.
15

Damage to the read surface, that is to say the surface through which the laser reads the data pits, will result in distortion of the laser beam, causing errors in the reading of data. Similarly, damage to the reflective layer will result in a loss of reflectivity and loss of data, which will also lead to errors in reading
20 of the data. A factor which is frequently overlooked is the possibility of damage to the reflective layer from the non-read side of the disc.

It is also desirable to avoid damage to the edge of the disc. If the edge becomes chipped, for example as a result of the disc being dropped, this may result in the reflective surface becoming exposed. In such circumstances, the
25 reflective layer may tarnish and peel off. The purpose of the reflective layer is to reflect laser light back into the detector device of the playback apparatus. If the metallised layer is no longer reflective due to tarnish, or if portions thereof are missing altogether, the playback apparatus will receive no data from the damaged portion of the disc and will therefore skip. Once exposure of the

reflective surface has occurred, it is difficult to stop progressive tarnishing and delamination. A disc damaged in this way rapidly becomes completely unplayable and must be replaced. Of course, in some cases, the stored data is unique and cannot be obtained from alternative sources.

- 5 From the foregoing, it is clear that any loss of laser light through dispersal is undesirable since this reduces laser intensity and may result in read errors. To combat this, manufacturers produce optical data storage media which have a degree of protection built in. The most vulnerable layers are the pitted surface, on which the readable data is stored, and the metallised layer.
- 10 During manufacture, these are sandwiched between layers of glass or plastics material which form part of the completed disc assembly. The manufacturing process may also include the provision of a label which is also provided with a protective coating.

15 The present invention is defined as a "semi-permanent" enclosure in order to distinguish it from protective layers such as those described above which are provided as an inherent feature of the manufacturing process.

- 20 In addition to read errors resulting from surface damage to the disc as outlined above, laser distortion may arise from non-planarity or imbalance of the disc, for instance due to wobbling of the disc in a playback apparatus. Such distortion is equally likely to result in read errors.

25 Protective shields for optical discs are known, for example as described in United States Patent No. 4,879,710. This patent discloses an optical disc protector comprising a transparent annular protective sheet provided with radially inner and outer rings of adhesive for securing the sheet to an optical disc. The adhesive rings are arranged so that they do not obscure the data portion of the disc. Such an arrangement suffers from the drawback that the film can be easily stripped at the edge of the disc due to the need for the contact adhesive bands to be very narrow so as not to overlie the data surface. Subsequent peeling of the film allows dust and other particles to become trapped under the film and to interfere with integrity of the laser signal. In severe cases, the film may be lifted sufficiently to cause interference with the mechanics of the playback apparatus.

In another protective arrangement known from United States Patent No. 4,736,966, an optical data storage device such as a data card is provided with a plurality of peelable transparent protective layers. When a layer becomes too severely scratched for efficient reading of data, it is removed by peeling. This approach has a number of disadvantages. Firstly, the data is obscured at the outset by the number of layers interposed between the read surface and the pick-up. This problem is exacerbated if the optical disc is intended for recording as well as playback, since the signal to be recorded will be attenuated by the interposed protective layers. Further attenuation occurs on reading, so the playback signal may be very weak and severely distorted. Another disadvantage is that the removal of successive layers by peeling leaves a residue of adhesive which needs to be cleaned away prior to playback. The very act of cleaning may damage the next layer of protective film.

In European Patent Application No. 0 375 298 A2, a protective shield for an optical disc is described which is designed to be stripped from the disc immediately prior to the recording of data thereon by laser irradiation. The shield thus serves to protect the disc in the post-manufacture phase, during storage, transport and purchase by an end user. Such shields are formulated with anti-static properties to minimise attraction of air-borne dust particles. This ensures that the data is recorded on a "clean" disc. However, no provision is made for protecting the disc after recording.

European Patent Application No. 0 300 733 A1 describes a heat-shrinkable shield for optical discs. One of the drawbacks of this arrangement is that specialist equipment is required to ensure even application of heat to the shield to effect shrinkage thereof around the disc to be protected. Temperature control is also important to prevent damage to the substrate. This arrangement is therefore unsuitable for use by non-experts.

In British Patent Application No. 2 217 507 A, annular protective shields are disclosed for attachment to compact discs through the intermediary of a transparent or translucent gum. A special apparatus is also disclosed for applying the shields to compact discs. The shields are shown attached to the non-read surfaces of discs, since the applicant believes that the non-read

surface is particularly vulnerable to damage by virtue of having only a relatively thin protective layer of u.v.-curable lacquer. Whilst there are undoubtedly some grounds for this belief, the document does not address the problem of protecting the read surface of optical discs from accidental damage.

5 It is therefore an object of the present invention to provide means for protection against accidental damage to the opposed faces and edge surface of an optical disc. It is a further object of the present invention to provide means for protection against accidental damage to an optical disc which is capable of being fitted by a non-expert and without the need for specialist equipment. It is also an object of the present invention to provide means for protection against accidental damage to an optical disc which means is capable of being kept in place during use of the disc in standard playback apparatus, including apparatus having a multiple disc magazine, and which fits into a standard disc "jewel" case for normal storage. It is yet another object of the 10 present invention to provide means whereby the dynamic qualities of an optical disc are enhanced during use by elimination or suppression of wobbling or other imbalances. It is a still further object of the present invention to provide 15 a method of repairing minor surface defects and blemishes in such discs.

In a first aspect, the invention is an enclosure for an optical data storage 20 device, said enclosure comprising a first planar transparent film dimensioned to overlie the read surface of an optical data storage device and a second planar transparent film dimensioned to overlie the non-read surface of said optical data storage device, characterised in that said first and second films are provided with rim means having an L-shaped cross-section said rim means 25 being dimensioned to extend around the periphery of the optical data storage device.

Preferably, the rim means comprises upper and lower rim components. The lower rim component may be formed of mild steel or material of similar strength and characteristics. The thickness of the material from which the 30 lower rim is made may range from 20 to 800 μm and its outside diameter may range from 80 to 140 mm, depending on the diameter of the disc to which it is to be applied. The lower rim component L-shaped cross-section is arranged

such that the vertical arm of the "L" surrounds the edge of the disc whilst the horizontal arm of the "L" forms a lip on which the lower face of the disc rests. It will be generally understood that the lower surface of a disc is the data read surface since the upper surface is usually provided with a label and is non-
5 reflective. Typical dimensions for the vertical arm range from 200 μm to 2.0 mm, whilst the horizontal arm may have a width of 200 μm to 30 mm. The selected width is chosen such that the lower rim component does not obscure any part of the data-carrying surface of the disc.

If the lower rim component is formed of metal, it is preferably factory-
10 fitted to a clear, glossy and optically perfect film which is formed with a hole in its centre. The hole has a diameter ranging from 14 mm to 60 mm and is dimensioned to accommodate the central raised spigot of a standard optical disc. The inside diameter of the film is chosen such that a film covering overlies the entire data-carrying surface of the disc. The film thickness may
15 range from 1 μm to 600 μm and the material of the film is chosen such that it permits passage of laser light without significant distortion or attenuation.

Alternatively, the lower rim component may be an up-turned lip formed integrally with the film.

Advantageously, the film destined for attachment to the read surface of
20 the optical disc may be coated with an optical couplant which assists in the establishment of an optically perfect interface between the film and the data read surface of the disc.

Preferably, the refractive index of the optical couplant is chosen to be as close as possible to that of the optical data storage device to which the film is
25 to be attached. Most preferably, the refractive index of the optical couplant differs by no more than $\pm 10\%$ and most conveniently by no more than $\pm 5\%$ from the refractive index of the surface of the optical data storage device to which it is attached in use.

30 Preferably, the optical couplant is a material, especially a silicone-based material, capable of flowing into minor defects on the surface of the optical data storage device. This capability allows minor blemishes and surface

asperities to be repaired so that playback losses are minimised and stored data is not compromised.

An especially preferred form of optical couplant is a blend containing silicone oil and inert fillers, such as the formulation sold under the Registered 5 Trade Mark "Rhodorsil" by Rhône-Poulenc. Rhodorsil Paste 4 has been found particularly suitable for attaching protective films to compact music discs.

Alternatively, the optical couplant may be a solid malleable material such as a transparent solid rubberised silicone or a transparent plasticised laminar coating, for example polyvinyl chloride (PVC), interposed between the optical 10 data storage device and the film. Such plastic coatings exhibit a cling effect similar to so-called "cling-films" and so cohere to the film and the surface of the optical data storage device. These solid optical couplants are preferably sufficiently conformable that they are able to creep into surface blemishes and effect repair in similar fashion to the fluid materials described above.

15 In another form of the invention, the film itself may perform the dual function of protective device and optical couplant without the need for separate adhesive or cohesive material/layers.

As indicated above, the optical couplant facilitates comprehensive joining between the film and the laser read surface of the optical data storage device. 20 No air or other contaminant is admitted between the two. The optical couplant can be adhesive or cohesive in its action, and is preferably peelable to allow removal of the film should this prove necessary. A protective enclosure in accordance with the invention may need to be removed, for example, if it becomes damaged and needs to be replaced with another.

25 Since optical discs are often formed with a plastics substrate such as polycarbonate or acrylic resins, it is particularly advantageous to use films formed from the same material. This ensures good optical matching between the film, the optical couplant and the optical disc to which the film is attached. Cellulose triacetate has also been found suitable, even in the absence of an 30 optical couplant.

A film is also attached to the non-read surface of the optical disc to ensure that its protection is comprehensive. This film may be a clear glossy

plastics material and is preferably arranged such that indicia provided on the non-read surface are still visible when the film is in place. The film need not be as optically perfect as the film used to protect the data read surface of the disc. The dimensions of the film for the non-read surface are most likely to be
5 similar to those for the film used on the data read surface. Most preferably, the film attached to the non-read surface is integrally-formed with a down-turned lip on its outer periphery which constitutes the upper rim component of the rim means and which co-operates with the aforementioned lower rim component. This upper film is also provided with a central hole to accommodate the central
10 spigot of the optical disc and may be coated with a contact adhesive on the surface thereof which is destined to make intimate contact with the non-read surface of an optical disc. The rim means may also have an adhesive coating to bond upper and lower rim components together and/or to bond it to the disc edge without causing interference to the laser read surface.

15 The rim means may have a reflective surface on the radially-inwardly directed portion thereof to reflect dispersed laser light back into the device and thereby minimise losses and reduce data read errors.

20 The provision of rim means has an additional benefit in that the mass of the rim creates an inertial effect as the disc is rotated in its record/playback apparatus. This means that the disc is less likely to wobble in the apparatus. A wobbling disc would result in laser light being reflected at non-ideal angles, causing loss or reduction of laser signal and possible errors in or failure of playback.

25 As indicated above, the rim means also protects the edge of the disc: If the edge becomes chipped or otherwise damaged, the shiny metal layer on the disc surface may be exposed and so become susceptible to peeling or tarnishing. Once again, this could result in loss or reduction of laser signal with its inevitable consequences for playback.

30 Another advantage of the rim means is that it can be configured to prevent the protective film surfaces from coming into contact with any planar surface on which the optical disc is rested.

The rim means may be provided as a pair of interengageable parts which snap together, one being applied in the direction of a first side (face) of an optical disc and the other being applied, in the opposite direction, from the other side of the device. The two rim portions are releasably engaged so that 5 they can be separated to allow removal of films if required.

In another variation, the rim means is provided with minute channels at the edges through which trapped air can be expelled. Such channels facilitate effective application of the films to the optical disc by ensuring that there are no discontinuities at the interface between the film and the optical disc.

10 Conveniently, an upper rim/film assembly is factory-supplied with a transparent contact adhesive so that it can be stuck to the top label surface of an optical disc and also grips the lower rim component to hold it in place.

15 The rim means is dimensioned to allow use of the present invention with magazines of optical discs with automatic changing apparatus, for example multi-disc CD players. Such rims must be sufficiently robust that they are capable of withstanding the handling forces encountered in the automatic changing apparatus whilst retaining the protective films in place.

20 In optical discs which are rotated at high velocity during playback, the rim means may perform a secondary function in preventing extrusion of the optical couplant from the outer extremity of the protective enclosure.

25 The rim components may be integrally formed with a respective film member, or may be separate therefrom. The rim means may be secured to a respective film member by welding or some other form of permanent bonding. If the rim component is metal, the reflective radially-inwardly directed surface may simply be the bright finish of the metal itself.

In a second aspect, the invention provides a method of repairing minor defects and/or blemishes on the laser read surface of an optical data storage device, the method being characterised by the following steps:

30 (a) applying a coating of an optical repair material to the laser read surface of said optical data storage device, at least in the vicinity of the defects and/or blemishes, and

(b) placing the disc in a semi-permanent enclosure in accordance with the first aspect of the invention described above.

Preferably, the step of applying the coating of optical repair material to
5 the laser read surface of the optical storage device is effected by:

- (i) providing a uniform layer of optical couplant on one face of the first planar transparent film member of the semi-permanent enclosure, said optical couplant having a refractive index compatible with that of the optical data storage device to be repaired;
- 10 (ii) placing the face of said first film member having the uniform layer of optical couplant against the damaged surface of the optical data storage device;
- (iii) squeezing any air from between the film and the optical data storage device, and
- 15 (iv) allowing the optical couplant to flow or creep into the damaged regions of the surface of said device.

This is possible because the optical couplant is of a nature which allows it to be moulded slightly. One particularly preferred optical couplant is a non-setting clear silicone paste with relatively high viscosity, such as Rhodorsil (RTM) Paste 4 described earlier.

The method defined above is capable of curing minor surface defects for as long as the film remains in place. The optical couplant flows or creeps into scratches and like surface blemishes to leave a surface which is readable by 25 incident laser without losing focus. If the film is removed, however, the damage will become apparent again once the surface is cleaned.

A more permanent optical couplant could be used which would remain in place after removal of the film and after cleaning.

The invention will now be described by way of example only with reference to the drawings, in which:

- Figure 1 is a view from below of one embodiment of the invention, showing an upper rim and a film member;
- 5 Figure 2 is a view from above of the arrangement depicted in Figure 1;
- Figure 3 is a view from above of a lower rim and film in accordance with the invention;
- Figure 4 is a view from below of the arrangement shown Figure 3;
- 10 Figure 5 is an exploded side view of upper and lower rims and films prior to their attachment to an optical storage device;
- Figure 6 is a side view in cross-section of the components shown in Figure 5 after assembly, and
- Figure 7 is a close-up view of the arrangement depicted in Figure 6, showing detail of the co-operating rims.

15

Referring now to Figures 1 and 2, these views show the bottom and top views, respectively of an upper rim 20 and film 30 for use with a laser-readable compact disc (not shown). The upper film 30 has a central cut-out 31 to accommodate a central boss of the compact disc. Typically, the diameter of 20 the cut-out 31 is arranged to be larger than the diameter of the central boss of the compact disc because the internal rim region of such bosses is utilised in reproduction equipment to centralise and grip the disc during playback.

Figure 1 shows a rim edge 21 which slightly overlies the outer periphery of the film 30, and a rim lip 22. The rim lip 22 should be regarded as 25 extending outwards from the plane of the drawing and is only shown here schematically as a circle surrounding the rim edge 21.

Figure 2 merely shows the rim edge 21 from above. In this view, the rim lip is not visible but may be regarded as projecting from beneath the plane of the drawing.

30 Figures 3 and 4 are similar views to Figures 1 and 2, except that they show top and bottom views, respectively of a lower rim 40 and film 50 for use with the laser-readable compact disc. Like its upper counterpart, the lower film

50 has a central cut-out 51 to accommodate the central boss of the compact disc. For the reasons given above, the diameter of cut-out 51 is larger than the diameter of central boss of the compact disc.

In Figure 3, a rim edge 41 is shown slightly overlying the outer periphery of the film 50. Rim 40 has a rim lip 42 shown here schematically as a circle surrounding the rim edge 41. This lip 42 should be regarded as extending outwards from the plane of the drawing. In Figure 4, rim lip 42 is not visible.

Figure 5 is an exploded view of the upper 20 and lower 40 rims and their respective film members 30 and 50, prior to attachment to a compact disc 60.

In practice, one of the upper or lower assemblies would be selected for attachment to a first surface of the compact disc 60. Any air bubbles which are trapped between the first surface of the disc and the film which is attached first are squeezed out by stroking the film gently in a radially outward motion. Conveniently, the rim members may be provided with minute channels at their edges through which trapped air can be expelled. Such channels are not shown in the drawings.

When the attachment of the first assembly to the first side of the disc is complete, the second assembly is offered up to the second face of the disc and the above process of air bubble removal is repeated. The respective rim portions are releasably clipped together to form a unitary retaining mechanism for the upper and lower films.

The fully assembled arrangement is shown in cross-section in Figure 6. Compact disc 60 is securely sandwiched between upper and lower film members 30 and 50 by the intermediary of fluid optical couplant such as the silicone preparations described previously.

Figure 7 is a close-up view of the interengaging rim members. In this view, the rim members are clearly shown as separate entities from their associated film members. However, as mentioned above, the rim members may be integrally formed with the film members or may be permanently bonded thereto such as by welding. It is also possible to have one film with an integrally-formed rim component and one film with a permanently-bonded rim

component, or combinations of the above with a separate rim and film sub-assembly.

The purpose of the protective cover on the laser read surface of the disc is to minimise or prevent scratch damage. Damage to this surface causes laser 5 light to be dispersed by reflection from the scratch which results in the data carried in that light being lost. The disc then skips. If the scratch is circular, it is more likely to impair the reading of the disc because the laser reads in a circular motion. Scratches across the disc are less of a problem because the laser can re-scan the disc to find the lost data, provided always that the 10 scratch is not too wide. Scratch damage near the centre of the disc may very well result in the entire disc being unplayable since the laser begins its scan here and must be able to identify the start of the recorded data. This is analogous to the start groove at the outer periphery of a gramophone disc tracked by a stylus.

15 Similar considerations apply in relation to the film applied to the non-read surface of a disc. Here, the purpose of the protective film is to prevent or minimise damage to the non-read surface to the extent that corruption of the reflective metallised layer is avoided. Minor blemishes on the non-read surface are not such a problem, but the enclosure of the present invention imparts an 20 extra degree of protection which contributes to the longevity of optical discs.

If the film is scratched, the damaged enclosure can be removed and replaced with a new unit having undamaged surfaces. In some embodiments, replacement of the defective part of the enclosure is all that is required and undamaged components can be re-used.

25 Where an optical couplant with favourable creep properties forms part of the enclosure, application of such an enclosure to a disc moderately damaged on its laser read surface is often sufficiently effective to cure the scratch damage and thereby restore the disc.

One of the main purposes of the rim means is to hold the enclosure in 30 place on a disc. It also acts, by virtue of its mass, as an inertia device which helps the disc to spin more evenly in the playback apparatus. To be effective in this role, the rim means should have a minimum mass of 1 gram. Discs tend

to wobble slightly in playback apparatus, which means that a small proportion of laser light is lost by reflection at non-ideal angles. Normally, a small decrease in light intensity is not a problem, but it can be critical if the disc is soiled by dust or fingerprints, for example. If wobbling coincides with a dirty 5 region of the disc, the laser intensity may drop to a level which causes skipping to occur. Hence, elimination of wobbling makes the playback apparatus more tolerant of surface imperfections on the disc.

As mentioned previously, another function of the rim means is to protect the disc edge from damage by chipping. However, the rim means is also 10 helpful in preventing surface damage to the disc because it raises the bottom surface of the disc slightly from any surface on which it might be placed when not in its storage case or in use.

Although the invention has been particularly described with reference to one preferred embodiment, it will be understood by persons skilled in the art 15 that various modifications are possible without departing from the scope of the claims which follow. For example, the invention may be adapted to optical data storage devices having two readable faces by using optically perfect films on both sides. In accordance with preferred variants, both such films may be provided with optical couplant on the face thereof which is brought into 20 contact against the surface of the device.

CLAIMS

1. An enclosure for an optical data storage device, said enclosure comprising a first planar transparent film dimensioned to overlie the read surface of an optical data storage device and a second planar transparent film dimensioned to overlie the non-read surface of said optical data storage device, characterised in that said first and second films are provided with rim means having an L-shaped cross-section said rim means being dimensioned to extend around the periphery of the optical data storage device.
2. An enclosure as claimed in claim 1 wherein the rim means comprises upper and lower rim components and wherein the lower rim component is formed of mild steel.
3. An enclosure as claimed in claim 1 or claim 2 wherein a uniform layer of optical couplant is provided on at least the first film, on the surface thereof to be attached to said optical data storage device in use, said optical couplant having a refractive index compatible with the refractive index of the optical data storage device.
4. An enclosure as claimed in claim 3 wherein the refractive index of the optical couplant differs by no more than $\pm 10\%$ from the refractive index of the surface of the optical data storage device to which it is attached in use.
5. An enclosure as claimed in claim 4 or claim 5 wherein the refractive index of the optical couplant differs by no more than $\pm 5\%$ from the refractive index of the surface of the optical data storage device to which it is attached in use.
6. An enclosure as claimed in any one of claims 3 to 5 wherein the optical couplant is a fluid material.

7. An enclosure as claimed in any one of claims 3 to 5 wherein the optical couplant is a solid malleable material interposed between the optical data storage device and the film or films.
8. An enclosure as claimed in any one of claims 3 to 5 wherein the material of at least the first film performs the dual function of protective device and optical couplant.
9. An enclosure as claimed in any one of claims 3 to 8 wherein the optical couplant is cohesive in its action.
10. An enclosure as claimed in any one of claims 3 to 9 wherein the optical couplant is peelable to facilitate removal of the film or films.
11. An enclosure as claimed in any preceding claim wherein the or each film is made from any material having laser light compatibility, including cellulose triacetate or a material the same as the substrate of the optical data storage device.
13. An enclosure as claimed in any preceding claim wherein the rim means has a reflective surface on the radially-inwardly directed portion thereof serving to reflect dispersed light back into the optical data storage device.
14. An enclosure as claimed in any preceding claim wherein the rim means comprises a pair of releasably engageable parts which snap together.

15. A method of repairing minor defects and/or blemishes on the laser read surface of an optical data storage device, the method being characterised by the following steps:

- (a) applying a coating of an optical repair material to the laser read surface of said optical data storage device, at least in the vicinity of the defects and/or blemishes, and
- (b) placing the disc in a semi-permanent enclosure in accordance with any one of claims 1 to 14.

16. A method as claimed in claim 15 wherein the step of applying a coating of optical repair material to the laser read surface of the optical storage device is effected by:

- (i) providing a uniform layer of optical couplant on one face of the first planar transparent film member of the semi-permanent enclosure, said optical couplant having a refractive index compatible with that of the optical data storage device to be repaired;
- (ii) placing the face of said first film member having the uniform layer of optical couplant against the damaged surface of the optical data storage device;
- (iii) squeezing any air from between the film and the optical data storage device, and
- (iv) allowing the optical couplant to flow or creep into the damaged regions of the surface of said device.

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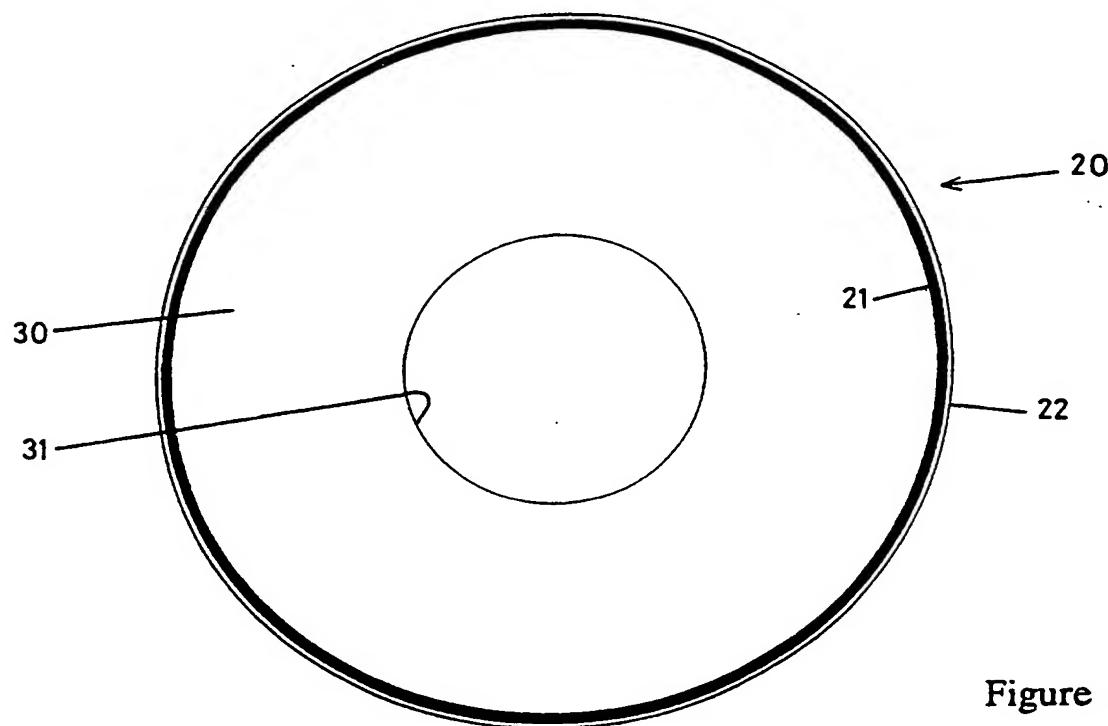


Figure 1

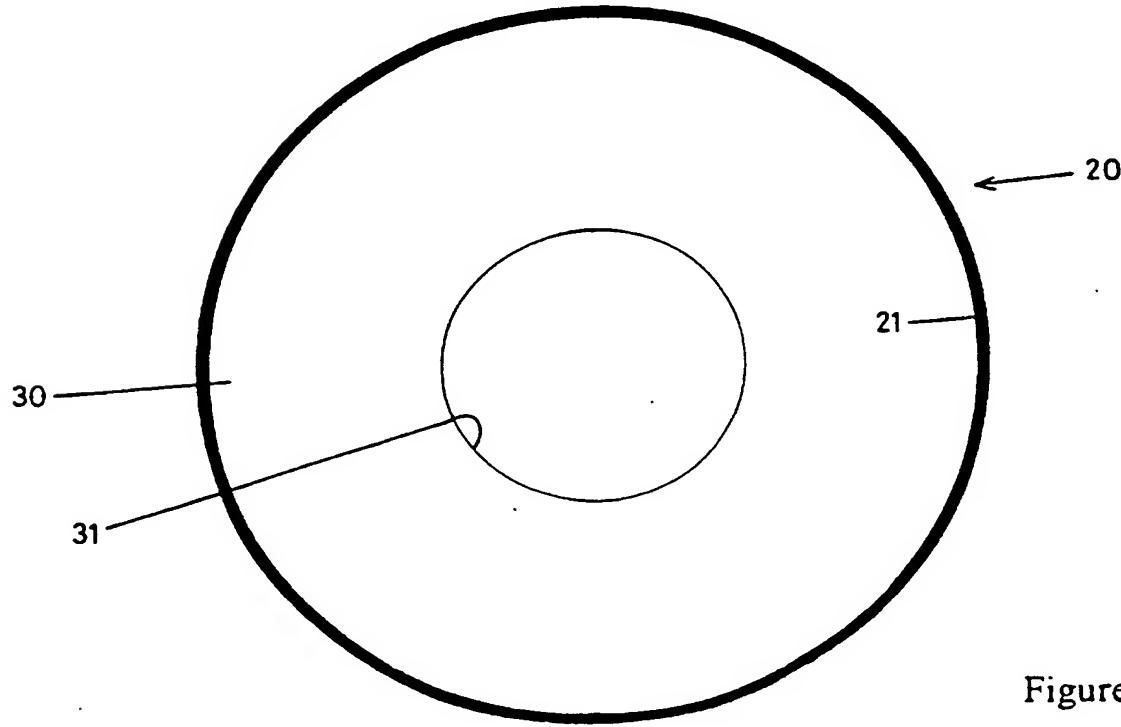


Figure 2

2/3

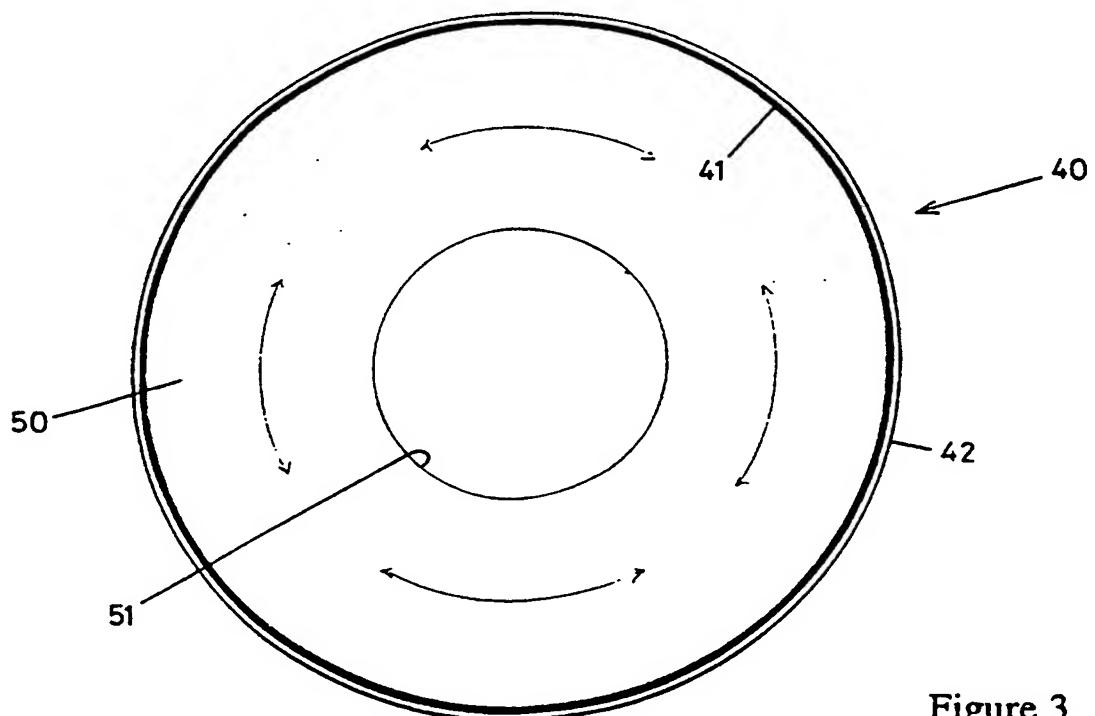


Figure 3

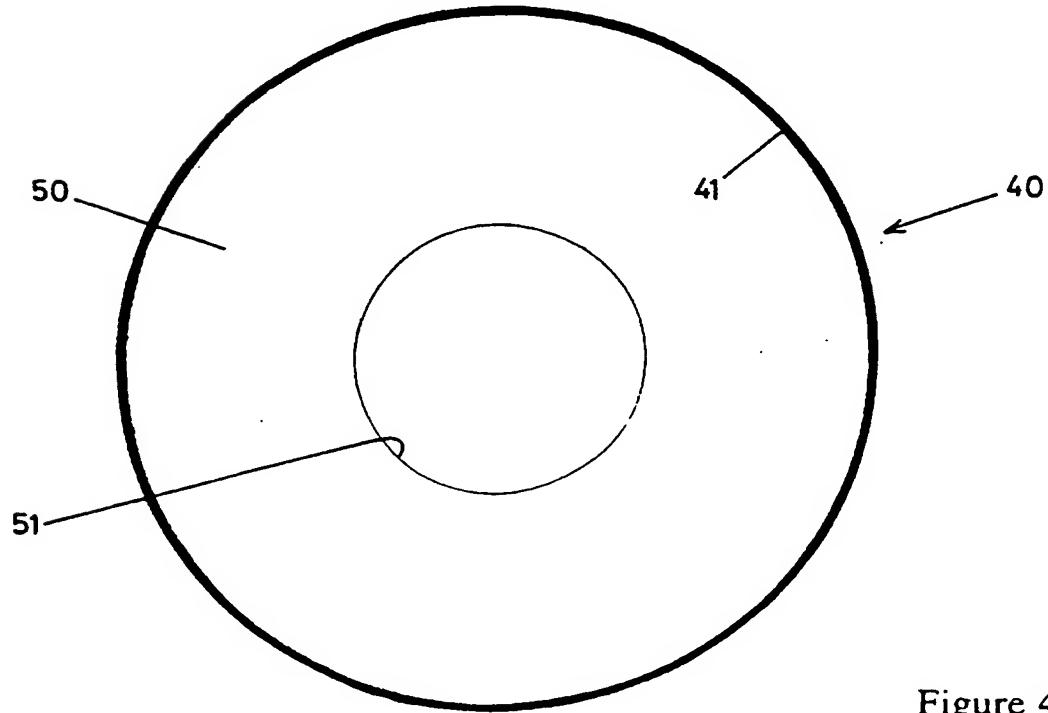


Figure 4

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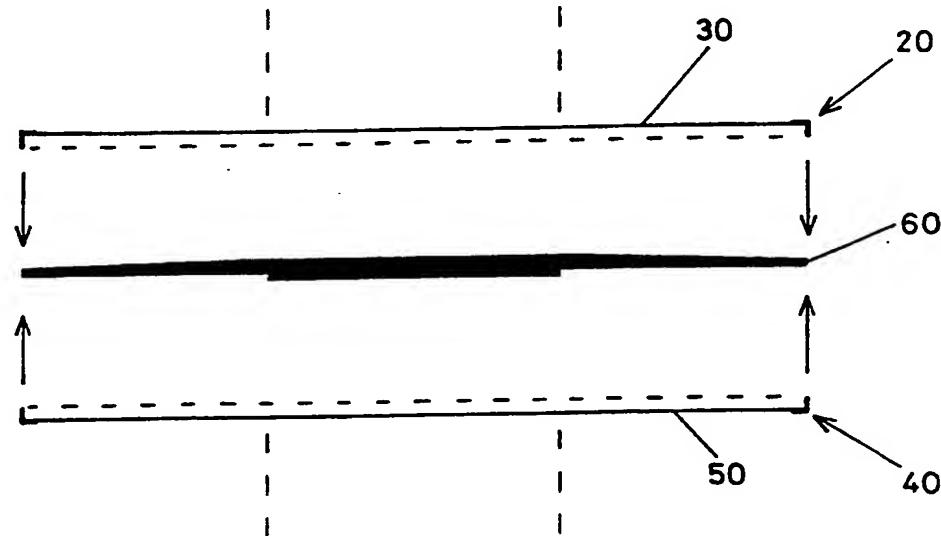


Figure 5

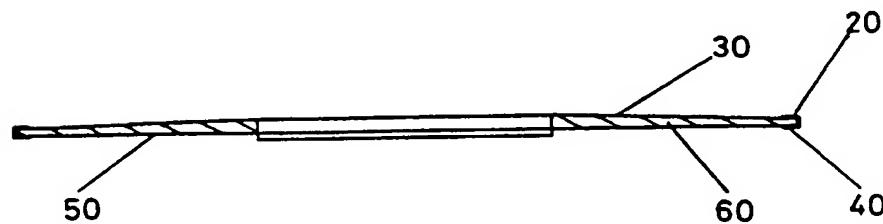


Figure 6

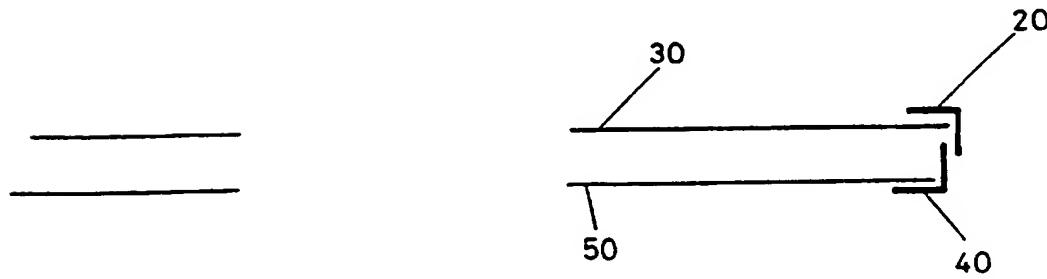


Figure 7

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 96/00036

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 G11B7/24 G11B23/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
 IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|----------|---|-----------------------|
| A | WO,A,94 14161 (FONIAS DOUKAS ROBERT ;KARAKYRIAKOS CON (AU)) 23 June 1994 see the whole document --- | 1,11 |
| A | US,A,4 879 710 (IIJIMA MUTSUO) 7 November 1989 cited in the application see the whole document --- | 1,11 |
| A | GB,A,2 217 507 (GUIVER THANE GERALD) 25 October 1989 cited in the application see the whole document --- | 1,7,9 |

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|-----------|---|-----------------------|
| A | PATENT ABSTRACTS OF JAPAN vol. 015 no. 095 (P-1176) ,7 March 1991 & JP,A,02 308440 (FUJITSU LTD) 21 December 1990, see abstract --- | 1 |
| A | PATENT ABSTRACTS OF JAPAN vol. 017 no. 020 (P-1469) ,14 January 1993 & JP,A,04 245039 (HITACHI LTD) 1 September 1992, see abstract --- | 3-5,8 |
| A | PATENT ABSTRACTS OF JAPAN vol. 013 no. 261 (P-885) ,16 June 1989 & JP,A,01 055756 (CANON INC) 2 March 1989, see abstract --- | 3-5,9 |
| P,X | GB,A,2 279 799 (BURROUGHS TREVOR ALAN) 11 January 1995 see the whole document ----- | 1,3-6, 9-11,14 |

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 96/00036

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|--|------------------|-------------------------|------------------|
| WO-A-9414161 | 23-06-94 | AU-B- 5620394 | 04-07-94 |
| US-A-4879710 | 07-11-89 | NONE | |
| GB-A-2217507 | 25-10-89 | NONE | |
| GB-A-2279799 | 11-01-95 | NONE | |

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